SIX NEW FOSSIL BIVALVES FROM THE EARLY MIOCENE OF AUCKLAND AND NORTHLAND, NEW ZEALAND

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Abstract. Six new fossil bivalve species are described from the Early Miocene of Auckland and Northland. All specimens were collected within the Waitakere, Waitemata, and Parengarenga Groups of the Akarana Supergroup. Two bathyal species, *Bentharca waitakarensis* n. sp. and *Euciroa (Euciroa) maoriana* n. sp., are from the Manukau Subgroup, Nihotupu Formation, Parekura and Maori Bay Members respectively. Four inner- middle-shelf species, *Paphies otaiana* n. sp., *Chama (Chama) hunua* n. sp., and *Austrovenus northlandica* n. sp. are from the Kawau Subgroup, Tipakuri Sandstone Member, and *Donax (Paradonax) parengarengaensis* n. sp. was collected from the Paratoetoe Formation, Te Pokere Mudstone Member. The genera *Bentharca* and *Donax* are new additions to the New Zealand fossil molluscan fauna. *Paphies otaiana* appears to be a phylogenetic precursor to *Paphies porrecta*, *P. donacina* and *P. subtriangulata*. *Austrovenus northlandica*, and *Chama (Chama) hunua* are the first species of these genera to be described from the Miocene of New Zealand.

KEYWORDS: Bivalvia; *Bentharca*; *Euciroa*; *Paphies*; *Chama*; *Austrovenus*; *Donax*; new taxa; Early Miocene; Waitakere Group; Waitemata Group; Parengarenga Group.

INTRODUCTION

Many of the Early Miocene sediments of Auckland and Northland are fossiliferous. They are diverse in both lithology and fossil content. Palaeobathymetry, palaeoclimate, volcanism and marine transgressions, largely influenced deposition and faunas during the Otaian and Altonian (Burdigalian). This paper describes new fossil taxa collected on field trips to Hays Stream (Hunua Ranges), Shaw Road quarry (Waitakere Ranges), and Maori Bay (Motutara), in the Auckland area, and to Paratoetoe Point (Parengarenga Harbour) in Northland (Fig. 1).

Fossil record numbers (e.g. R12/f72) are those of the Geological Society of New Zealand Fossil Record File. Specimens are held in the marine invertebrate collections, Auckland War Memorial Museum (prefix AK); the palaeontological collections, Geology Department, University of Auckland (L); and the author's collection (ME). Palaeoecological and palaeoenvironmental assessments are based on the known ecology of genera living today and of modern species most closely related to these fossils. Systematics and nomenclature follows Cox *et al.* (1969), and Beu *et al.* (1990).

PREVIOUS WORK

Hays Stream, Hunua Ranges, south-east Auckland
Eagle & Hayward (1992) reviewed past studies at this site, recording 131 macrofossil and 97 foraminiferal taxa from Hays Stream, adding fish, barnacles and polychaetes to previous faunal
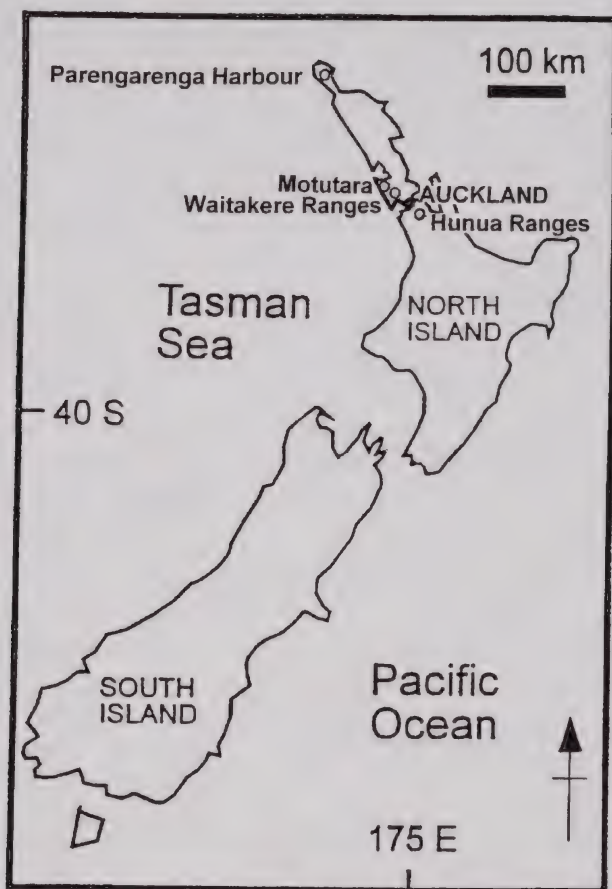
Fig. 1. Map of New Zealand showing northern North Island fossil localities of specimens collected and described in this paper.

lists. Fossils from the Waitakere Group, Kawau Subgroup, Tipakuri Sandstone Member (Hayward & Brook 1984; Eagle 1992a) from fossil locality R12/f72 (1:50 000 NZMS 260 grid reference R12/863566), northern Hunua Ranges, were collected by Hayward, Hollis, de Carteret, and Eagle in January 1992 and by Hayward and Eagle in February 1992. Macrofossil and microfossil biostratigraphy confirm an Early Miocene, Otaian (Burdigalian) age (Eagle & Hayward 1992). For a geological map of the area see fig. 1 of Eagle & Hayward (1992).

Shaw Road quarry, Waitakere Ranges
Macrofossils were first discovered in the 1930s at the Shaw Road quarry, Oratia, in the Waitakere Ranges, Auckland (Fig. 2). Collections made by Hulme and Schofield, New Zealand Geological Survey, during mapping and sampling in 1961, were placed in the Geological Survey collections, Lower Hutt. These collections were used by Hayward (1979) in his discussion of deep Miocene faunas from the region. Microfossil evidence (Hayward 1983) suggests that these middle Altonian faunas are the youngest known marine sediments in the eastern Waitakere Ranges. Fossils were collected by Eagle in March 1989 and by Grant-Mackie and Eagle in February 1990.
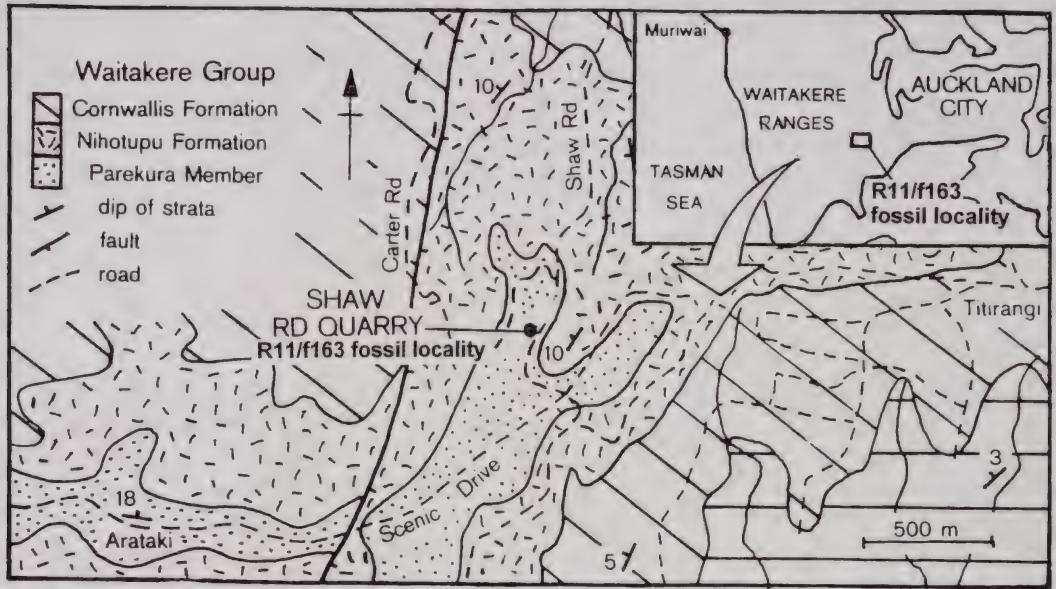
Fig. 2. Schematic geological map showing location of the Shaw Road quarry fossil locality, Waitakere Ranges (after Hayward 1979).
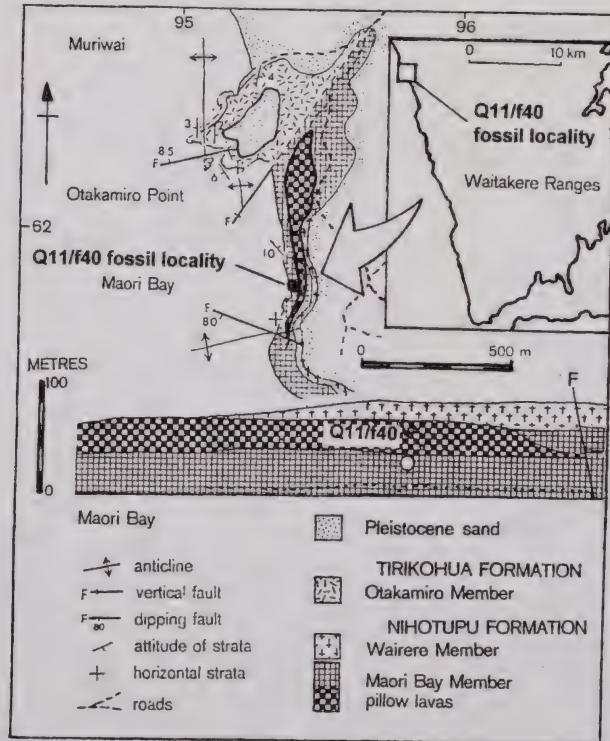

Fig. 3. Schematic geological map showing location of the south Maori Bay fossil locality, Motutara, north-west Auckland (after Hayward 1979).

South Maori Bay, Motutara, north-west Auckland

Powell (1935) described specimens collected from sparsely fossiliferous tuffs underlying pillow-lavas in the coastal cliffs at the south end of Maori Bay (Fig. 3). Bandy *et al.* (1970) K/Ar-dated the andesitic pillar lavas (16.8 Ma), used in turn to date a planktonic foraminiferal datum level within the upper part of the Early Miocene. Hayward (1979) mapped and named the strata here and further along the south coast as well as describing new fossil taxa (Hayward 1981). Eagle (1992b; 1999) described a new deep-water chemoautotrophic lucinid bivalve and a sea star from Motutara. Fossils from the Waitakere Group, Manukau Subgroup, Nihotupu Formation, Maori Bay Member (Hayward 1976a) from fossil locality Q11/f40 (1:50 000 NZMS 260 grid reference Q11/378840) were collected by Eagle in July 1990. Microfossil evidence confirms a mid-Altonian (Burdigalian) age (Hayward & Buzas 1979).

North shore, Parengarenga Harbour

Kear & Hay (1961), Leitch (1966, 1970) and Brook (1989) mapped the northern Parengarenga and North Cape area. Ballance (1974) outlined the principal palaeogeographic features, including Early Miocene sedimentary basins in Auckland and Northland. Wakefield (1976) named new lithographic units and fossil tax from both Otaian and Altonian sequences outcropping on the north shore of Parengarenga Harbour. Grenfell (1984) described fish otiliths collected from Parengarenga Harbour Early Miocene fossil localities. Fossils from the Parengarenga Group, Paratoetoe Formation (Leitch 1970), Altonian fossil locality NO2/f231 (1:50 000 NZMS 260 grid reference NO2/055444) (Fig. 4), were collected by Stace, Morley, Hayward and Eagle in October 1992.
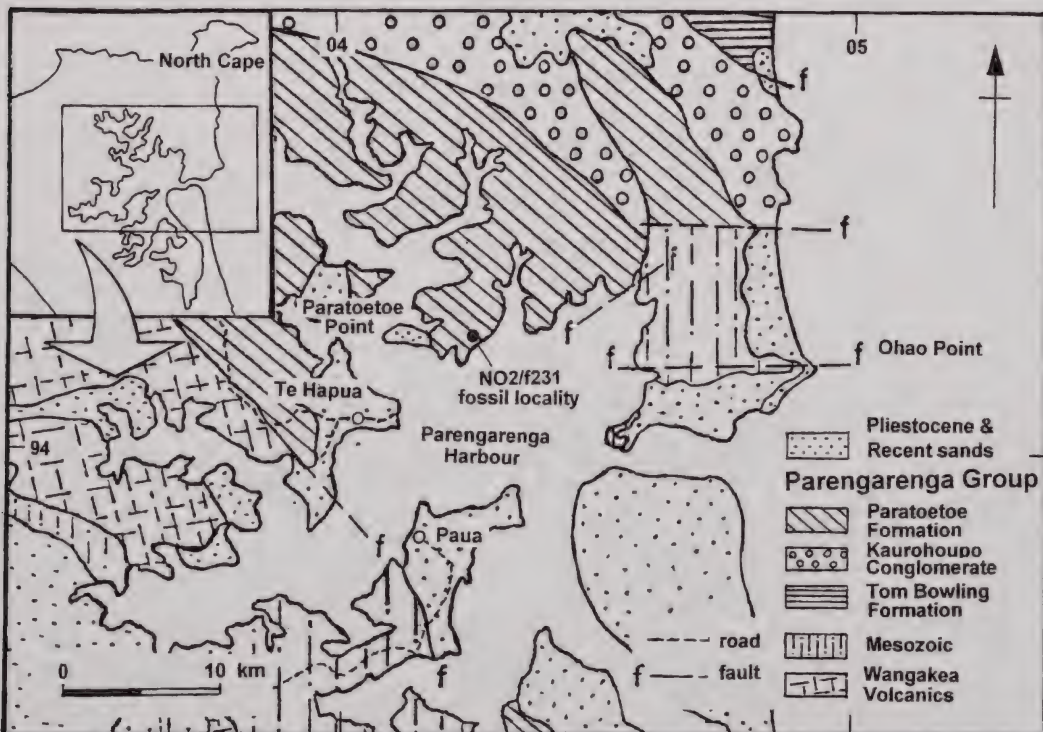

Fig. 4. Schematic geological map showing location of the Paratoetoe Formation fossil locality, north shore, Parengarenga Harbour (after Wakefield 1976).

GEOLOGICAL SETTING

REGIONAL

Early Miocene rocks occur throughout Auckland and Northland. They are characterised by warm water biotas poorly preserved in weathered outcrops of great lateral variation related to contemporous volcanism and tectonism (Beu *et al.* 1990). Weathered outcrops include various lithologies such as pillow lavas, volcanic breccia and tuff beds. The Late Oligocene and Early Miocene rocks of northern New Zealand were reviewed by Ballance *et al.* (1978) who proposed the Akarana Supergroup with seven groups, three of which are relevant to this paper—Waitemata Group (Ballance 1976), Waitakere Group (Hayward 1976b), and Parengarenga Group (Wakefield 1976). A deep marine Waitemata Basin covered the Auckland region in Early Miocene times. This basin was large and was flanked east and west by volcanic arcs which produced the lavas and volcaniclastic sediments of the Waitemata Group and Waitakere Group (forming the present-day Waitakere Ranges). Sediments of the Parengarenga Group were deposited in outer-shelf to upper bathyal zones as submarine canyon-fan down-slope sediments within a regional back-arc basin (Ballance 1974).

SPECIFIC SITES

Hunua Road cutting, Hays Stream, Hunua Ranges, south-east Auckland

Eagle & Hayward (1992) reviewed the geology of this site. The Hunua Road cutting fossil fauna is preserved as decalcified to good-quality specimens in a bed of muddy, shelly conglomerate. The particular fossil bed in which specimens were collected is 3.5 m above the cutting on the first bend in the Hunua Road east of the road bridge, at the start of the gorge. The fossil bed appears to have been mixed preburial during downslope transport in a sub-aqueous gravity flow. Occassional fossils are found within ripped-up clasts which are deposited irregularly throughout the unit.

Shaw Road quarry, Waitakere Ranges (Fig. 2)

The Shaw Road quarry consists of coarse volcaniclastic lithofacies of the Parekura Member, Nihotupu Formation, Waitakere Group (Hayward 1976b, 1976c). The Parekura Member consists predominantly of massive beds of pebbly volcanic breccia-conglomerate with a discontinuous layer (<1 m thick) of interbedded fine volcaniclastic grit, sandstone, and siltstone that constitutes, in part, a bathyal flysch (Sporli 1983). These accumulated seafloor sediments suggest a transported filling of an earlier fossil submarine canyon or distributory channel (Hayward 1979). The Shaw Road quarry is "perhaps the deepest-water molluscan faunule yet recorded from New Zealand" (Beu *et al.* 1990), containing only a few taxa, all of which are diagnostically bathyal. Foraminfera indicate deposition in 1000-2000 m (Hayward & Buzas 1979).

South Maori Bay, Motutara, north-west Auckland (Fig. 3)

The Maori Bay early Miocene post-depositional upthrown fault bock is part of a major group of four that are separated by three northeast-striking faults along the Muriwai-Te Waharoa (Motutara) coastline. The 1.2 km Maori Bay block is folded into a broad anticline with an ENE plunging axis (Hayward 1976a; 1983). The location of the Maori Bay Member type section is coincidental with the new fossil species type locality. Holocene and early Miocene sands immediately overlie pillow lava high in the stratigraphic sequence of south Maori Bay. The Maori Bay Member (Hayward 1979), south Maori Bay, is located within the Nihotupu

Formation, Waitakere Group, Manukau Subgroup (Hayward 1979). The lithofacies exposed in the coastal sequence at south Maori Bay consists of muddy volcarenite (containing coarse pumice lapilli), that are well-bedded and hydrothermally altered. The unit contains few taxa, all of which indicate a bathyal depth (Hayward 1979, Beu *et al.* 1990).

North shore, Parengarenga Harbour (Fig. 4)

The Parengarenga Group, Paratoetoe Formation (Leitch 1970), on the north shore of Parengarenga Harbour, is part of an extensive submarine canyon-fan complex deposited in the Late Otaian—Early Altonian as part of the Parengarenga Group. The Paratoetoe Formation contains a distinctive fossiliferous unit that is a massive, blue-grey fine to medium sandy-siltstone flysch unit 20 m thick that forms high, eroded cliff sections on the north and south sides of Paratoetoe Penninsula. The mudstone unit is moderately consolidated and shows few diagenetic features. The most extensive section exposed at Te Pokere, north-west Paratoetoe Point, has steeply eroded slopes 45 m high. The section possesses an abundant, diverse, well-preserved marine fossil fauna. The mudstone unit is also exposed and more readily accessible along the north Parengarenga Harbour shoreline, just south of Waipatukohu Stream to Paratoetoe Point. Fresh exposures are reduced in this section by weathering along tensional fault systems, creating massive debris slopes littered with exhumed Early Miocene Mollusca (Wakefield 1976, Beu *et al.* 1990).

Although massive, the mudstone contains occasional concentrations (some showing faint parallel laminae) of molluscan shell material, and vague shell lineations that parallel indistinct bedding planes. Calcareous fossils retain their original mineralogy, wood fragments are carbonised, and vertebral bone fragments have been partially silicified. Bioturbation is excessive, with individual ichnofauna barely discernable. Irregular tubular and ellipsoidal calcitic concretions occur erratically in cliff sections, eventually weathering out, falling down-slope, finally concentrating on the shore platform. On the shore platform between Waipatukohu and Waiomoko Streams, large cylindrical concentrations have developed around simple, tubular, 25 mm diameter ichnofossils, approximately normal to the indistinct bedding. Several ferruginous cemented, irregularly shaped, rough mounds, 0.3-0.5 m high and 0.2-0.4 m wide, are also to be found on the shore platform, eroded from strata above. They apparently developed by the preferential weathering of entwined ichnofossils from within the massive mudstone cliffs.

SYSTEMATICS

CLASS: BIVALVIA Linnaeus, 1758
SUBCLASS: PTERIOMORPHIA Beurlen, 1944
ORDER: ARCOIDEA Lamarck, 1809
SUPERFAMILY: ARCACEA Lamarck, 1809
FAMILY: ARCIDAE Lamarck, 1809
SUBFAMILY: ANADARINAE Reinhart, 1935
GENUS: *Bentharca* Verrill & Bush, 1898
Type species: *Macrodon asperula* Dall, 1881 (by original designation). Recent, Gulf of Mexico.

Diagnosis: Shell equivalve, compressed, inequilateral, umbones in anterior quarter; outline subtrapezoidal; anterior greatly restricted; posterior margin broadly rounded, expanded; anterior margin indented by byssal sinus; dorsal margin long and straight; ligament restricted to posterior area; hinge plate narrow; teeth in two series separated by edentulous gap; sculpture of faint radial striae; adductor muscle scars indistinct, unequal (Cox *et al.*1969; Knudsen 1970).

Bentharca waitakarensis n. sp. (Figs 5-8, 9, 12)

MATERIAL
Holotype: L3833, adult specimen exterior (Fig. 5), interior (Fig. 6). Paratypes: L3834, block with both valves complete (Fig.7). L3835, two blocks with single right valve on one and the external cast on the other. L3836, block with single left valve. L3837, partially broken left valve. L3838, broken left valve with articulated steinkern and broken left valve. AK72301, single right valve. ME9001, articulated specimen with conjoined valves (Fig. 8).

TYPE LOCALITY
Specimens are from the Waitakere Group, Manukau Subgroup, Nihotupu Formation, Parekura Member (Hayward 1976b), fossil localities R11/f160 and R11/f163, Shaw Road quarry, Oratia, Waitakere Ranges, West Auckland (Fig. 2).

AGE
Middle Altonian Stage (Burdigalian), based on foraminiferal faunas (Hayward 1983) and correlated molluscan faunas collected from other dated localities within the Waitakere Group.

DISTRIBUTION
Known only from the Shaw Road quarry.
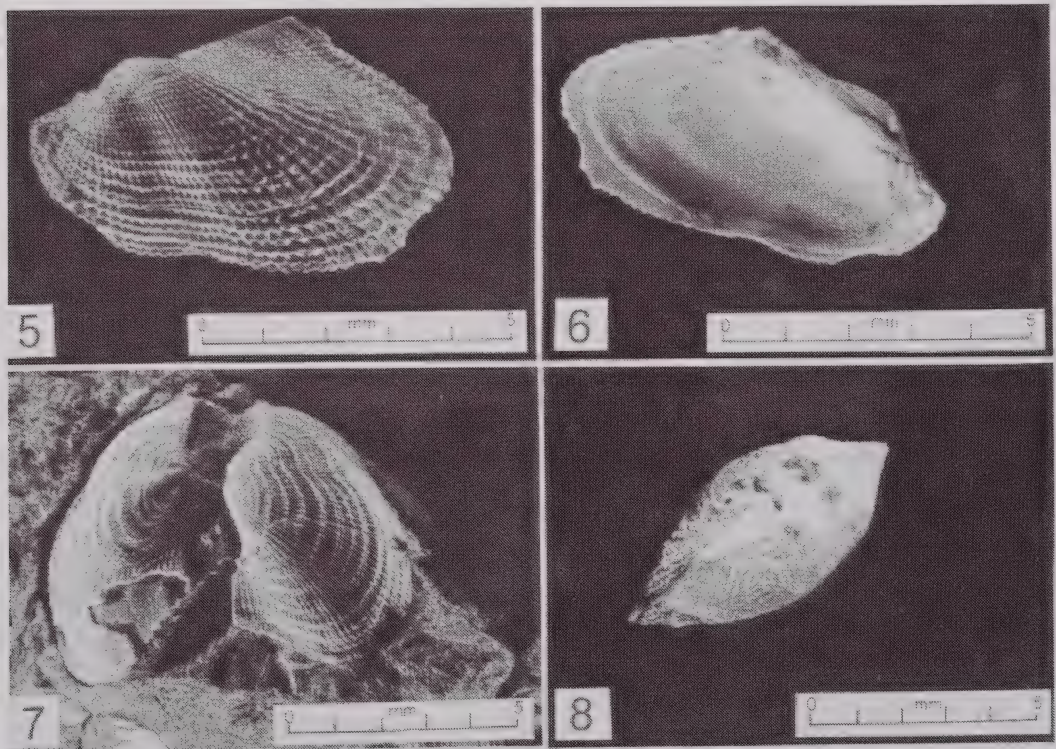
Figs 5-8. *Bentharca waitakerensis* n. sp. 5. Holotype L3833, left valve exterior. 6. Holotype L3833, left valve internal. 7. Paratype L3834, oblique dorsal view of articulated shell. 8. Paratype ME9001, conjoined valves.

ETYMOLOGY
Named after the Waitakere Ranges.

DESCRIPTION
Small, thin-shelled, equivalve, inequilateral. Shell outline obliquely subpyriform, dorsal extremities angular, umbone situated at about anterior third, beak broadly pointed, prosogyrous. Posterior and anterior margins subparallel, oblique, posterior about twice length of anterior margin. Anterior margin curves gently to form a shallow embayment in outline becoming the broadly convex sweep of ventral margin. Posteroventral margin narrowly rounded marking distal end of prominent postumbonal ridge. Inflation of anterior region causes shallow anteroventral sulcus forming marginal embayment corresponding to shallow gape in commissure plane in right valve. Shell sculpture strong, decussate, with radial and commarginal ridges. Ligament duplinvicular, elongate, very narrow. Hingeline straight, occupying 5/6 of shell length, with gently arched dental series consisting of small, oblique, subequal, short, smooth, undivided teeth, which converge ventrally and diminish in size medially. Anterior dental series slightly shorter, more irregularly shaped than posterior, both separated by a postumbonal edentulous gap less than half postumbonal hinge length. Posterior aductor muscle scar irregular with an anterodorsally directed linguoid projection. Anterior adductor muscle scar elevated, smooth, subquadrate, with no obvious growth marks. Interior ventral margin curves dorsally, uninterrupted and smooth. Meristics: Table 1 gives measurements of *Bentharca waitakarensis* n. sp.

Table 1. Measurements (mm) of *Bentharca waitakarensis* n. sp.

Specimen	Height	Length	Inflation	Post-umbonal length
holotype L3833	5.2	9.1	2.9	4.0
paratype L3834	4.8	8.1	2.3	3.9
paratype L3835	3.1	7.2	2.1	2.7
paratype L3836	3.2	7.0	2.3	3.0
paratype L3837	4.0	7.1	2.3	3.2
paratype L3838	4.1	7.9	2.3	3.2
paratype AK72301	4.1	7.6	2.4	3.0

REMARKS
The Shaw Road arcid has been variously allocated to *Notogrammatodon* (Hayward 1979) and the genus *Bathyarca* of which numerous species have been described from the Cenozoic fossil record. The genus *Bentharca* was originally created to separate the bathyal-abssyal Recent species *Bentharca asperula* (Dall, 1881) (Figs 10, 13) from other species of *Bathyarca*. Beu *et al.* (1990) tentatively included the new fossil species in *Bentharca*, an allocation consistent with morphologic characteristics and inferred depositional depth.

The early Miocene fossil is similar to *B. asperula* (Dall, 1881), *B. nodulosa* (Muller, 1776) (Figs 11, 14) and *B. xenophoricola* (Kuroda, 1968), in its small size and shell height, but it is more elongate and has a more reduced inflation in the posterior quadrant. Hinge lines of all four species are long and straight, that of *B. waitakerensis* having five almost horizontal posterior
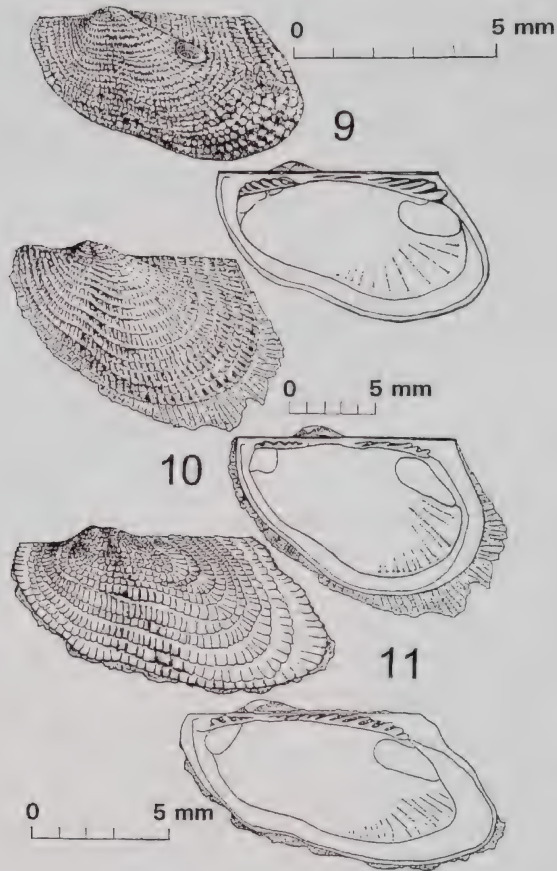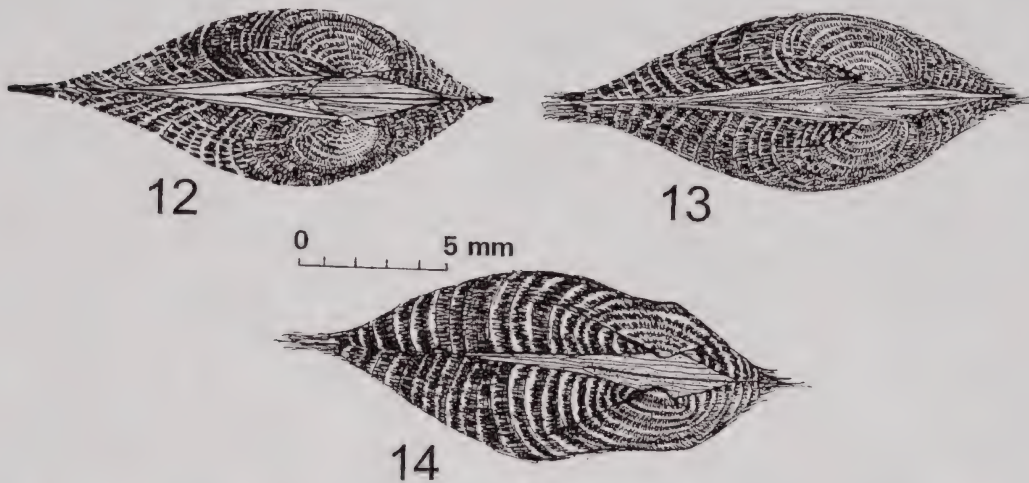
Figs 9-11. Line drawings of *Bentharca* species showing shell outline, sculpturing and internal morphological features. 9. *Bentharca waitakerensis* n. sp. 10. *B. asperula* (after Cox *et al.* 1969). 11. *B. nodulosa* (after Knudsen 1970).

and eight anterior teeth, whereas *B. asperula* has only four posteriorly and six anteriorly. Knudsen (1967) studied shape variation in the shell of *B. asperula* and intraspecific variation in the position and number of hinge teeth. The degree of variation in *B. waitakerensis* is similar. Unlike comparable Recent species, *B. waitakerensis* lacks myophoric ridges or shelves, has a posterior adductor muscle scar that is more irregular in outline with an anterodorsally directed linguoid projection, and a subquarate anterior muscle scar that is more elevated, with no obvious growth tracks. The overall shape, dentition arrangement, differences in shell sculpture and internal muscle scars, all differentiate *B. waitakerensis* from other known bentharcids.

    Bentharca is a suspension filter-feeder, byssally attached to a hard substrate. It dwells in areas of deep-flowing turbidity currents that convey suspended nutrient-rich organic material. Prehistoric turbidity currents that flowed through the Shaw Road submarine canyon sustained the benthic fauna with food then destroyed it by an inundation of volcanoclastic sediment. Associated macrofauna collected at the fossil locality (e.g. *Saccella motutarensis* Powell, 1935; *Vaginella aucklandica* Clarke, 1905; *Bathytoma mitchelsoni* Powell, 1935) have modern analogues

Figs 12-14. Line drawings of *Bentharca* species showing details of escutcheon, umbo and lunule. 12. *B. waitakerensis*. 13. *B. asperula*. 14. *B. nodulosa*.

in bathyal and abssyal assemblages. Some microfossils at the Shaw Road quarry site were probably displaced downslope by submarine mass debris flows (Ballance & Gregory 1991), as is apparent in adjacent localities (Hayward 1976c). Sufficient microfossil evidence is, however, associated with *B. waitakerensis* to suggest that the byssally-attached bivalve lived at 1000-2000 m (Hayward & Buzas 1979). Naticid and other borings are evident on several specimens, indicating benthic predation by carnivorous Mollusca.

The Shaw Road bathyal-abssyal zone possibly had temperatures of 4-10°C, consistent with the findings of Bruun (1956, 1957). A eurythermal-eurybathyal genus such as *Bentharca* could possibly cope with benthic temperature fluctuations during the gradual transformation from warmer Middle Altonian sea conditions to those of the present day. Distribution of Recent *Bentharca* indicates the genus has a temperature tolerance of 1.1-11.7°C; 75% of *B. asperula* are from water cooler than 4° with 50% of these living at abssyal depths below 3° (Knudsen 1967). Recent *B. asperula* occurs in the Atlantic Ocean, northern Indian Ocean, southeast Asian waters, north-west Pacific Ocean, the Tasman Sea and the Kermadec Trench, with a known depth of 430-3005 m (Knudsen 1970). Recent *B. nodulosa* and *B. xenophoricola* are temperate species. The close morphological similarily between *B. waitakerensis* and *B. asperula* suggests an ancestor-decendant relationship.

The deep-sea fauna is rich in archaic forms, and the cold bathyal-abssyal depths of the world's oceans have been a refuge for certain molluscs (Ekman 1953). The Arcidae is a conservative family as evidenced by its long and continuous fossil record extending back to the Triassic. General shell characteristics in the Arcoidea have remained stable over those hundreds of millions of years (Newell 1965). *Bentharca* is likely to have remained comparatively unchanged for so long because it persisted in the deep sea.

SUBCLASS: HETERODONTA Neumayer, 1884
ORDER: VENEROIDEA H. Adams & A. Adams, 1856
SUPERFAMILY: MACTRACEA Lamark, 1809
FAMILY: MESODESMATIDAE Gray, 1839

GENUS:	*Paphie*s Lesson, 1831. For diagnosis see Cox *et al.* (1969 and Beu & de Rooij-Schuiling (1982).
Type species:	*Paphies roissyana* Lesson, 1830 (original designation; = *Mya australis* Gmelin, 1791). Recent, South Pacific.

Paphies otaiana n. sp. (Fig. 15)

MATERIAL

Holotype: AK72652, left valve (juvenile?) embedded in sandstone matrix; Waitakere Group, Kawau Subgroup, Tipakuri Sandstone Member (Hayward & Brook 1984), Hunua Road cutting R12/f72.

AGE

Macrofossil and foraminiferal biostratigraphy confirm an early Miocene, Otaian (Burdigalian) age (Eagle & Hayward 1992).

ETYMOLOGY

Named for its Otaian age.

DESCRIPTION

Shell small, solid, moderately thick, low, oval, strongly inequilateral, elongate, long. Anterior end rounded. Shell height 15.1 mm, length 23.8 mm, inflation 4.1 mm. Posterior end weakly convex, posterodorsal area convex. Umbo highest point on shell, beak at posterior third. Shell
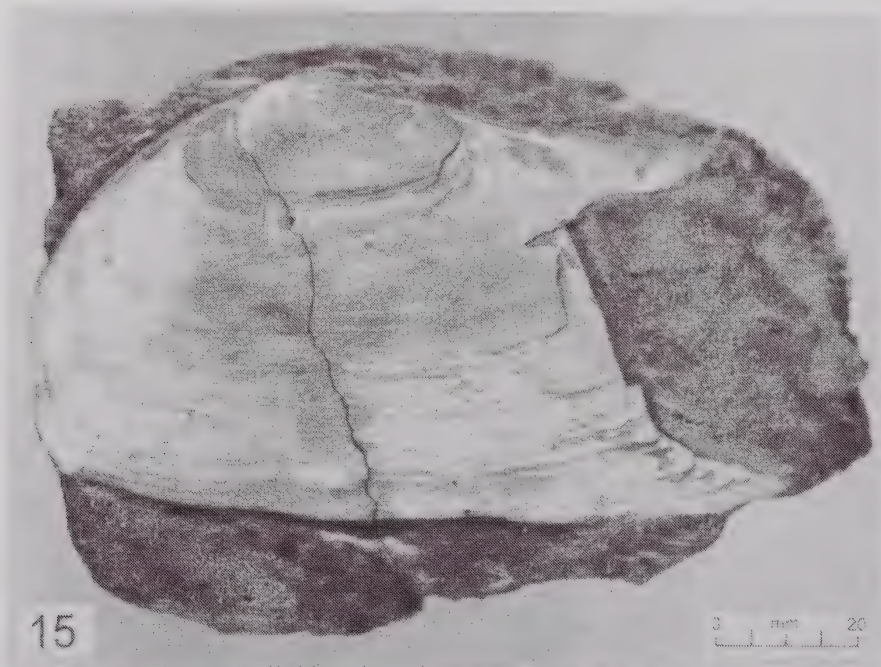

Fig. 15. Lateral view of holotype of *Paphies otaiana* n. sp. (AK72652).

unsculptured with low, smooth, commarginal growth ridges prominent distally. Hinge line thick, narrow. Shell interior infilled by indurated sandstone matrix.

REMARKS

Four Recent species of *Paphies*, *P. australis* (Gmelin, 1791), *P. subtriangulata* (Wood, 1828), *P. donacina* (Spengler, 1793), and *P. ventricosa* (Gray, 1843), are common around mainland New Zealand, Chatham Island, and Auckland Island coastlines. A Chatham Island *Paphies* form living at Petre Bay, previously thought to be a living example of the Neogene fossil *P. porrecta* (Marwick, 1928), was synonomised by Smith *et al.* (1989) with *P. subtriangulata*. The known fossil record of *Paphies* is sparse. Pleistocene and Pliocene specimens have been collected at well-known Quaternary localities such as the Rangitikei Valley, Kai-iwi, Castlecliff (Wanganui Basin), and Titirangi in the Chatham Islands. One species, *Paphies anteaustralis* (Dell, 1950), has been described from the Miocene (Beu 1971). Cenozoic exposed sandy coast facies are rare and associated fossil faunas are correspondingly rare.
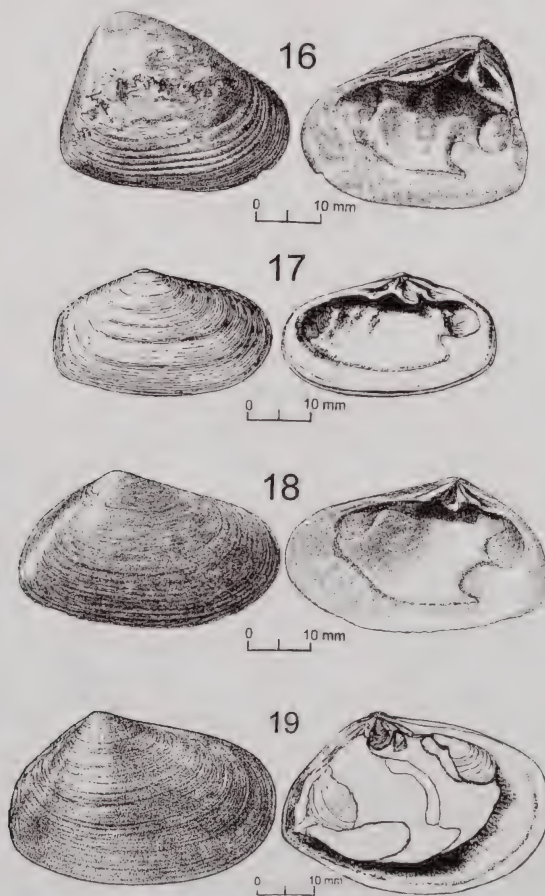
Figs 16-19. Line drawings of New Zealand fossil and Recent *Paphies* species. 16. *Paphies crassiformis* (from Beu *et al.* 1990). 17. *P. subtriangulata*. 18. *P. porrecta* (from Beu *et al.* 1990). 19. *P. ventricosa* (external view from Suter 1915).

The Cenozoic fossil record contains seven species: *P. anteaustralis* (Otaian), *P. australis* (Nukumaruan-Recent), *P. crassiformis* (Marshall & Murdoch, 1920) (Nukumaruan), *P. donacina* (Mangapanian-Recent), *P. porrecta* (Nukumaruan), *P. subtriangulata* (Haweran-Recent), and *P. ventricosa* (Castlecliffian-Recent) (Beu *et al.* 1990). Several fossil and Recent species are similar to *P. otaiana* n. sp., although because of hinge-line, overall shape, and comarginal growth variations, *P. anteaustralis* and *P. australis* are not. Most specimens of *P. crassiformis* (Fig. 16) are more triangular than *P. otaiana* and possess a very heavy hinge-line. Some of the forms of *P. crassiformis*, however, are not always so triangular, may have the posterior considerably longer than the anterior end, and may show more resemblance to the northern species *P. subtriangulata* (Fig. 17). Holocene *P. subtriangulata* from The Bluff, Ninety Mile Beach, and Recent specimens from Long Bay, Auckland, also have an excessively heavy hinge (Stace 1996). The northern and southern species *P. donacina*, which is morphologically similar to *P. subtriangulata*, is characterised by a subtriangular shape, a rather short anterior end and a less posterior beak than that of *P. subtriangulata* and a broad, expanded posterodorsal area. *P. otaiana* is not considered conspecific with *P. crassiformis*, *P. subtriangulata*, or *P. donacina* because of its more elongate, narrower overall shape, a more widely rounded anterior dorsal margin, a more weakly convex posterior end and a less angled posteroventral extremity. *P. otaiana* is similar to *P. porrecta* (Fig. 18) and *P. ventricosa* (Fig. 19) in morphology, but is more narrowly elongate, possesses a fuller and more rounded anterior dorsal margin that is not as truncated, has a weaker rounded ridge from umbo to ventral curve of anterior margin, is not as inflated, and has growth ridges parallel to ventral and dorsal margins. Of all New Zealand *Paphies* species, the extant *P. subtriangulata* is the most similar to *P. otaiana*.

The notion that *Paphies* may have migrated to New Zealand during the Pliocene (where they first appear in large numbers) is based on the proliferation of species with no known fossil progenitors. The discovery of a second *Paphies* species in the early Miocene suggests otherwise. *P. anteaustralis* and *P. otaiana* were either probable direct ancestors to *P. australis* and *P. subtriangulata-P. donacina* respectively, or ancestral to unknown *Paphies* forms that migrated away from the southern biotic province post-Otaian, only to return pre-Nukumaruan. Alternatively, *Paphies* progenitors may have existed, but have not been preserved or discovered. A lack of suitably preserved facies would explain the absence of pre-Neogene progenitors for *P. ventricosa* and *P. donacina*.

SUPERFAMILY: CHAMACEA Lamark, 1809
FAMILY: CHAMIDAE Lamark, 1809
GENUS: *Chama* Linnaeus, 1758
Type species: *Chama (Chama) lazarus* Children, 1823 (by subsquent designation). Recent. Australia, central Pacific, Phillipines, Indonesia, Malayasia, central Indian Ocean, California, Ecuador, Galapagos Islands.
Diagnosis: Shell small to large; variable sculpture, well developed, usually concentric, sometimes radial, or both; shell sessile at least temporarily; umbones prosogyrate; ligament and resilium external, situated in a deep groove; hinge usually with a minute or obsolete posterior lamina in fixed valve; one large cardinal tooth in either valve, two cardinals and weak laterals in some; adductor scars unequal; pedal scars minute and distant (Cox *et al.* 1969).
SUBGENUS: *Chama* Linnaeus, 1756
Diagnosis: Concentric ornamentation of distinctive flattened spines in irregular radial rows (Cox *et al.* 1969).

Chama (Chama) hunua n. sp. (Figs 20-23)

MATERIAL

Holotype: AK 72655, single right valve, umbone prosogyrate (Fig. 20). Paratypes: L3938 (Fig. 21), single right valve, internal; AK 72657 (Figs 22, 23), single left valve, umbone opistogyrate; Waitakere Group, Kawau Subgroup, Tipakuri Sandstone Member (Hayward & Brook 1984), Hunua Road cutting.

DISTRIBUTION

Known from Hays Stream (Northern Hunua Ranges), Waitakere Ranges, and Pakurangi Point (Kaipara Harbour) (Beu *et al.* 1990).

ETYMOLOGY

Named after the Hunua Ranges.

DESCRIPTION

Shell large for genus, length to 80 mm, greatly inflated, heavy, thick-walled, external layer prismatic in structure. Right valve free, subcircular, length greater than width, height 30-78 mm, length 30.2-80 mm, inflation 13.2-24.8 mm. Shell sculpture elaborate with commarginal
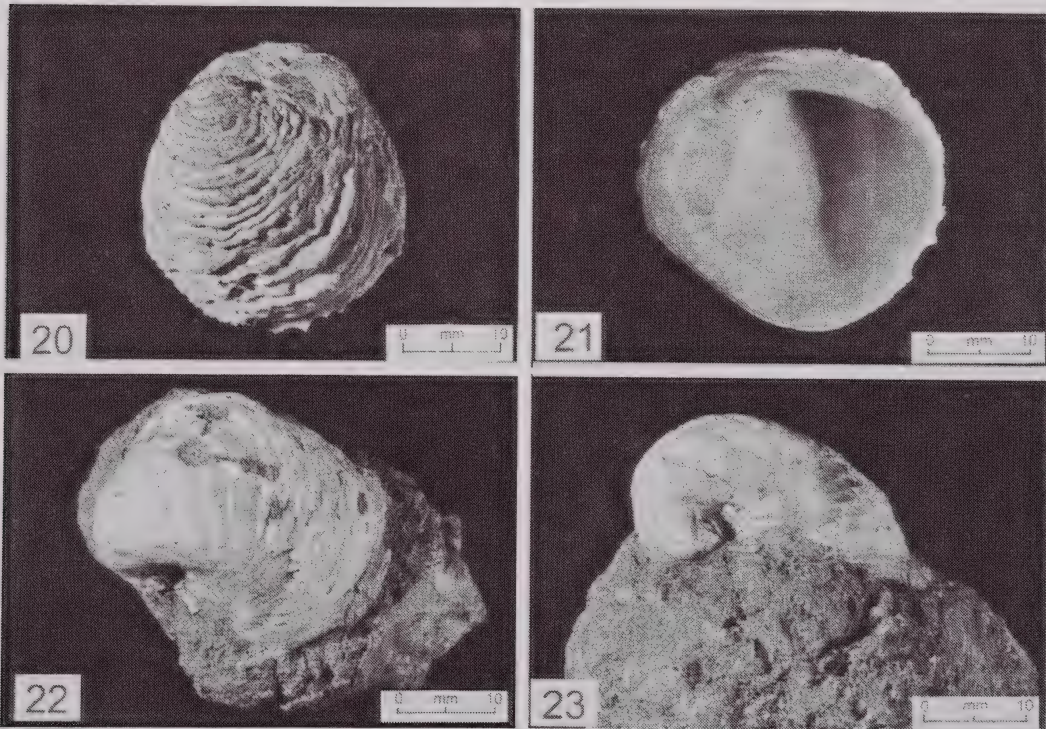
Figs 20-23. *Chama (Chama) hunua* n. sp. 20. Holotype AK72655, right valve lateral external view. 21. Holotype AK72655, right valve lateral internal view. 22. Paratype AK72657, left valve dorsal view showing ?predatory borings. 23. Paratype AK72657, left valve showing opistogyrate umbone.

rows of elevated, broad-frilled, thin, finely spinose growth ridges rather than distinct lamellae bearing fine radial grooves and ridges. Umbone prominent, dorsally elevated, strongly developed, spirally coiled, prosogyrate. Right hinge with prominent socket, upper side strongly, crudely rugose, situated on lower portion of plate. Cardinal tooth elongate, crude with narrow lower ridge that borders distal margin of deeply incised ligmental groove. Interior ventral margin smooth, aragonitic porcellaneous. Adductor muscle scars unequal, large, ovate, anterior smaller than posterior. Pallial line continuous. Shell interior surface roughened with short, irregularly meandering lines or grooves. Left valve sessile, height 36.1-81 mm, length 37-76.2 mm, inflation 27.9-51 mm. Umbone strongly inflated, opistogyrate; beak curled inward. Aperture subcircular, length greater than width. Hinge and valve internal surface not seen.

REMARKS

The New Zealand Pliocene species *Chama huttoni* (Hector, 1886) from Castlepoint (Nukumaruan) and another Cenozoic chamid, *C. pittensis* Marwick, 1928 (Waipipian) from Pitt Island, Chatham Islands, are the only named fossil species of this genus from New Zealand. Right valves of *Chama* species have been found at many early Miocene localities, among them Pakurangi Point, Clifden, and the Waitakere Ranges. Left *Chama* valves, such as those of *C. (Chama) hunua* are extremely uncommon. An undescribed, possibly new chamid found in early Eocene rocks of Mangaporapan age from the upper Waihao River, South Canterbury (Beu *et al.* 1990) has not been compared with *C. (Chama) hunua.*

Beu *et al.* (1990) described an unnamed *Chama* species (Fig. 24) from Target Gully, Oamaru (Altonian), that "is possibly conspecific with *C. huttoni*" (although exhibiting more distinct radial sculpture on the commarginal lamellae). Beu *et al.* (1990) also questioned the validity of *C. pittensis* by suggesting that it is "doubtfully distinct from *C. huttoni*". They commented on a chamid similar to *C. (Chama) hunua* recorded from Otaian beds in Northland as being distinct from all three species by virtue of its larger size (with a length up to 80 mm) and "finely spinose growth ridges rather than distinct lamallae".

Several extant chamids are similar to *C. (Chama) hunua*. *C. lazarus* Children, 1823 (East Indies and Australia; Fig. 25), is longer (to 100 mm), and unlike the New Zealand fossil possesses prominent, foliated (not imbricate) concentric commarginal lamellae and a beak that is not as strongly prosogyrate. The Australian *C. pulchella* Reeve, 1846 is shorter (to 50 mm) than *C. (Chama) hunua* and also has foliated concentric commarginal lamellae. A distinct difference between the two species is that *C. pulchella* has rows of foliacious ridges separated by a furrow from the umbones to the postero-ventral margin. Another extant Australian species, *C. ruderalis* Lamarck, 1819, is also shorter (to 35 mm), and differs from the New Zealand fossil species in that the right valve is quite flat compared with the inflation seen in *C. (Chama) hunua*, the imbricated commarginal lamellae bear spines which become longer posteriorly, and the beak is not as raised nor as spirally prosogyrate as that of *C. (Chama) hunua*. The Central American species *C. buddiana* C. B. Adams, 1852 (Fig. 26) is a much lighter, thinner shell and up to four times longer (to 120 mm) than *C. (Chama) hunua*. It also differs in having an elaborate sculpture of rows of elevated, fluted isolated spines.

Also similar to *C. (Chama) hunua* is the Baja, California, Miocene-Recent *C. squamuligera* Pilsbry & Lowe, 1932 (Fig. 27). *C. squamuligera* is much smaller (to 21 mm) than *C. hunua*, has concentric commarginal lamellae that are foliated with closely set, long, narrow spines on the right valve, and an internally granulose broad edge on the right valve. The extant cosmopolitan and Pliocene fossil *C. frondosa* Broderip, 1835 (California to Ecuador and the Galapagos; Fig. 28), differs from *C. (Chama) hunua* in that the heavy shell is smaller (to 75 mm) and concentric commarginal lamellae extend into the longitudinally plaited foliations. Fossil *C. lamellifera* Tenison-
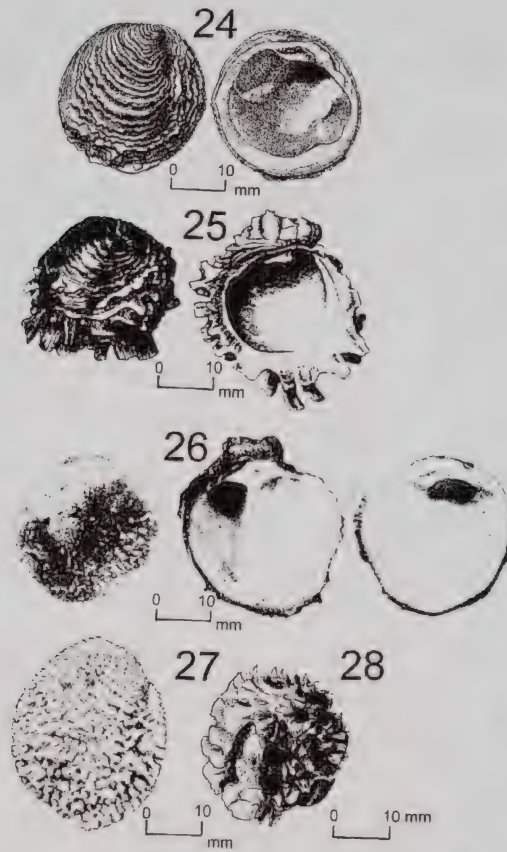
Figs 24-28. Line drawings and monochromes of New Zealand fossil and Recent foreign *Chama* species. 24. *Chama* sp., right valve lateral external and internal views of Altonian, Target Gully specimen (from Beu *et al.* 1990). 25. *C. lazarus*, lateral external view of right valve and internal view of left valve (from Cox *et al.* 1969). 26. *C. buddiana*, external lateral view of right valve, internal lateral view of left and right valves. 27. *C. squamuligera*, lateral view of right valve. 28. *C. frondosa*, lateral view of right valve. (Figs 26-28 from Keen 1958.)

Woods, 1877 from the early Miocene of Table Cape, Tasmania, is smaller (to 24 mm) than *C. (Chama) hunua*, is similar in not having radiating striae, but lacks the finely spinose growth ridges that *C. (Chama) hunua* has. *C. (Chama) hunua* possesses features that together characterise it as being unlike any other chamid. The left valve of *C. hunua* was cemented to the substrate, verifying it as a *Chama* and not *Pseudochama* (Oligocene- Recent), which is attached by the right valve.

Contemporary *Chama* are sessile in shallow (0-100 m), warm waters in sub-equatorial latitudes. They wedge in crevices and attach to coral, stones, or shell masses in subtidal reef systems, boulder banks and shell hash accummulations. They often become overgrown with algae, their spines become ground down by abrasion or encrused with sediment and marine growths. Consequently, fossil chamids are usually collected abraided and broken. Right valves of *C. (Chama) hunua* are in good condition, possibly because they disarticulated soon after death and were quickly buried. The paratype left valve of *C. (Chama) hunua* is decalcified,

abraided, and has been bored, possibly by carnivores. Early Miocene New Zealand chamids are palaeotemperature indicators of a warmer geologic stage.

SUPERFAMILY:	TELLINACEA de Blainville, 1814
FAMILY:	DONACIDAE Fleming,1828
GENUS:	*Donax* Linnaeus, 1758
Type species:	*Donax rugosa* Schumacher, 1871 (by subsequent designation). Recent, West Africa.

Diagnosis: Trigonal shells, medium-sized to small, solid, inequilateral; radial sculpture present in most, at least as marginal crenulations; periostracum wanting; opisthogyrate; hinge with two cardinals, well developed laterals; pallial sinus normally present; posterior area concentrically wrinkled, internal margin strongly denticulate (Keen 1958; Cox *et al.* 1969).

SUBGENUS:	*Paradonax* Cossmann & Peyrot, 1910
Type species:	*Donax transversus* Deshayes, 1830 (by original designation). Miocene, France.

Diagnosis: Possessing low radial sculpture, smaller than *D. (Donax)* with lower beak; posterior laterals strong in right valve (Cox *et al.* 1969).

Donax (Paradonax) parengarengaensis n. sp. (Figs 29-30)

MATERIAL

Specimens partially broken, abraided, and decalcified (Figs 29-30). Holotype: AK 72653, left valve (top). Paratypes: AK72654 and L3937, both left valves (middle and bottom respectively). Parengarenga Group, Paratoetoe Formation, north shore, Parengarenga Harbour, NO2/f231.

AGE

Macrofossil and foraminiferal biostratigraphy confirm an early Miocene, Altonian (Burdigalian) age (Leitch 1970; Beu *et al.* 1990).

DISTRIBUTION

Known only from the Paratoetoe Formation, Parengarenga Harbour.

ETYMOLOGY

Named after Parengarenga Harbour, Northland.

DESCRIPTION

Shell small, solid, narrowly elongate, porcellaneous, subtrigonal. Anterior side longer than posterior, more broadly rounded. Posterior side shorter than anterior, narrower, inflation low, height 6.3-7.2 mm, length 12.3-13.9 mm, inflation 1.6-2 mm. Beak situated between posterior one-third and one-quarter, low. External sculpture of faint and weak fine radial ribbing, with punctate interspaces and occasional concentric growth striae. Nymphal plate a narrow lunate platform extending posteriorly from beak along dorsal margin. Hinge with two small cardinal teeth and one lateral tooth in right valve. Left valve accommodating sockets. Distinct pallial line, moderately large rounded pallial sinus extending nearly to valve centre. Internal margin crenulate, reflecting radial ribbing. Posterior adductor muscle scar small, ovoid. Anterior adductor muscle scar large, rhomboidal. Right valve unknown.
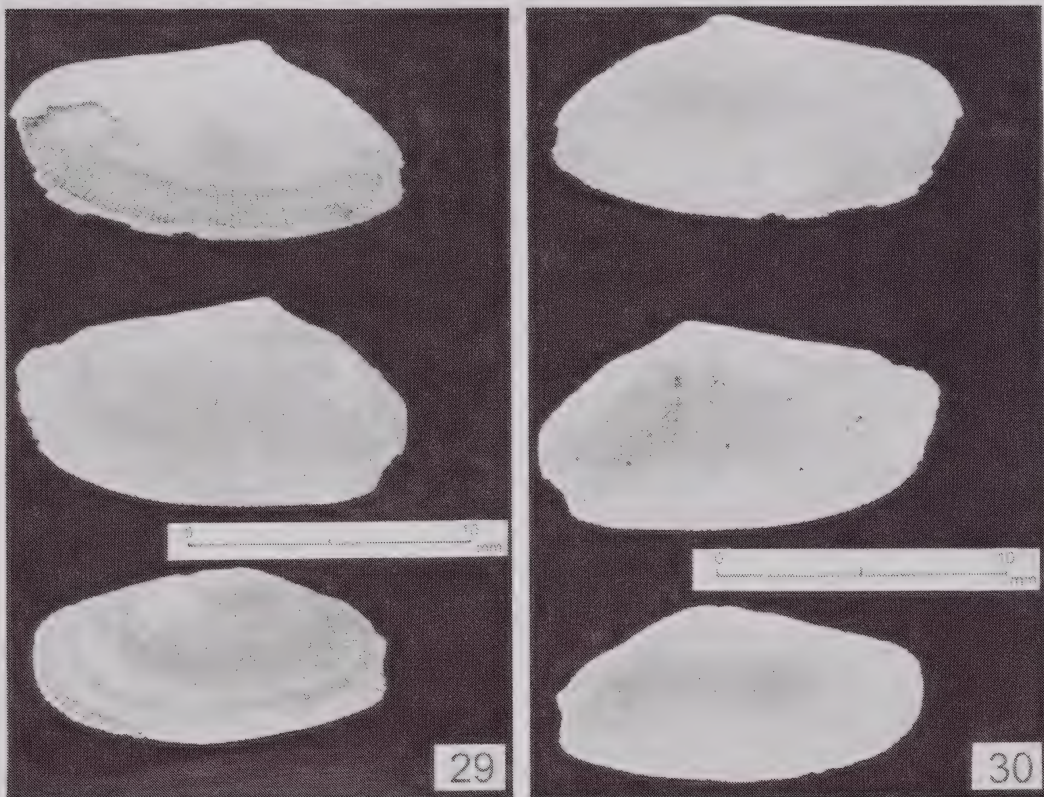
Figs 29-30. *Donax (Paradonax) parengarengaensis* n. sp. 29. Holotype AK72653, paratypes L3937 and AK72654 (top to bottom respectively); lateral view of external shell. 30. Holotype AK72653, paratypes L3937 and AK72654 (top to bottom respectively); lateral view of internal shell.

REMARKS

Shells of *Donax (Paradonax) parengarengaensis* are very small as members of the genus go. However, they are presumed to be adult, or are current-sorted, since all valves collected are of a similar size. The French Miocene fossil and subgenus type species *D. (Paradonax) transverus* Deshayes, 1830 (Fig. 31), is more trigonal in outline than *parengarengaensis*, possesses a nearly straight anterodorsal line compared to the variously curved one of *parengarengaensis*, and is gently truncated anteriorly with the anteroventral margin rising dorsally in a sharper curve. The two strong lateral teeth sockets of *paregarengaensis* are thinner and longer than those of *transversus,* and positioned at a steeper inclination on the hinge line. In both fossil species the shell inflation and internal crenulate ventral margin are similar.

Compared to *D. (Paradonax) parengarengaensis*, the Recent (Gulf of California to Panama) *Donax navicula* Hanley, 1845 (Fig. 32) has a shell that is more rounded ventrally, more rhomboidal in outline and more inflated. *D. navicula* is higher (10 mm), longer (21 mm), and has a greater inflation (3.9 mm). The uncommon, Mexico to Panama, Recent *D. petallinus* Reeve, 1854 (Fig. 33) is also a small, elongate shell, although bigger (height 11 mm; length 22 mm; inflation 3.3 mm) than *parengarengaensis*. The ventral margin of *D. petallinus* is deeper,
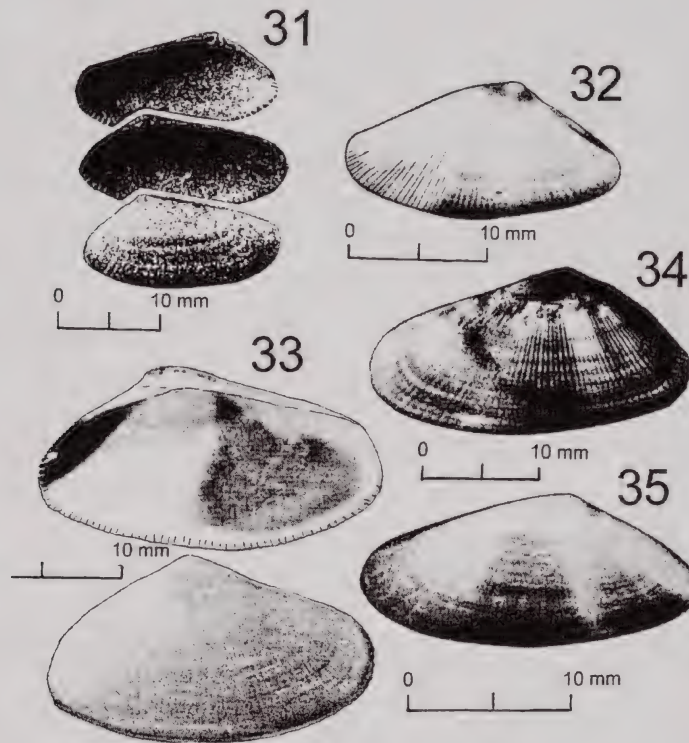
Figs 31-35. Monochromes and line drawings of Recent *Donax* species. 31. *Donax (Paradonax) transversus*, lateral views of internal left and right valves and external view of left valve. 32. *D. navicula*, lateral view of right valve external. 33. *D. petallinus*, lateral view of right valve internal and left valve external. 34. *D. contrusus*, lateral view of right valve external. 35. *D. gracilis*, lateral view of right valve external (all from Keen 1958).

and the outline becomes more ovoid than that of *parengarengaensis*. The also uncommon, Recent *D. contrusus* Reeve, 1854 (Fig. 34) is similar to *parengarengaensis* in having finely punctate spaces between the ribs, however, it is larger (height 16 mm; length 30 mm; inflation 5.5 mm), has differently shaped adductor muscle scars, and a coarser radial ribbing. The Recent *D. gracilis* Hanley, 1843 (Fig. 35) is the most similar in shell outline and sculpturing to *parengarengaensis*. This Peruvian species has a polished, elongate shell with the beak nearer the posterior end, like *parengarengaensis*, although it is twice the size of *parengarengaensis* (height 9.4 mm; length 22.5 mm; inflation 3.0 mm), has a differently orientated dentition, and has different shaped adductor muscle scars. Compared to Recent species of Australian *Donax*, *parengarengaensis* is more ovally-elongate, has a lower umbo, and appears from the left valve sockets to have strong posterior lateral teeth in the right valve. *D. (Paradonax) parengarengaensis* is unlike any known *Donax* because of a unique combination of morphological features, including shell outline, dentition, and internal scar arrangements. It is the only fossil record of the genus in New Zealand.

SUPERFAMILY: VENERACEA Rafinesque, 1815
FAMILY: VENERIDAE Rafinesque, 1815
SUBFAMILY: CHIONINAE Frizzell, 1936

GENUS: *Austrovenus* Finlay, 1926
Type species: "*Venus stutchburyi*" Gray in Wood, 1828 (by original description). Recent,
                  New Zealand.
Diagnosis: See Finlay (1926) and Cox *et al.* (1969).

Austrovenus northlandica n. sp. (Figs 36-39)

MATERIAL

Holotype: AK 72649 (Fig. 36). Paratypes: AK 72650 (Fig. 37), L3939 (Fig. 38), AK76821, AK76823 (Fig. 39). All adult (?) specimens; Waitakere Group, Kawau Subgroup, Tipakuri Sandstone Member (Hayward & Brook 1984), Hunua Road cutting, R12/f72.

DISTRIBUTION

Known only from the Hunua Road cutting.

ETYMOLOGY

Named after the Northland region of the North Island of New Zealand.

DESCRIPTION

Shell small for genus, solid, oval, height slightly less than length, height 14.1-14.6 mm, length 14-16.8 mm, inflation 4.8 mm, thick, moderately inflated, convex. Umbo low, protruding. Lunule large, unimpressed, radially ribbed, bordered by shallow depression. Margin in posterodorsal quadrant flattened, broadly rounded. Prominent commarginal cancellate sculpture of 42-47 radials. Concentric lamellae of nearly equal strength. Radial costae low, wide, rounded, flat-topped, with interstices intersected by thin, low, well-spaced, lamellae, regular near umbo, irregular near ventral margin. Ligmental nymph prominent, deep. Escutcheon defined by absence of radials, flat, narrowly lanceolate in both valves. Hinge-teeth divergent. Right valve with thick, bifid cardinal teeth and with, weak posterior lateral ridge. Left valve broadly-triangular, grooved, median with long, high, curved, posterior cardinal welded to nymph. Anterior lateral socket present. Pedal retractor scar near anterior adductor scar which is slightly narrower than posterior, both deeply impressed. Ventral margin of valve internal, bicrenate with two orders, both projecting inward and bordering ventral margin. Second order with more crenulations. Pallial line almost entire with small sinus, short, narrow, triangular, ascending.

REMARKS

The New Zealand Recent and fossil *Austrovenus* record has been complicated by the genus *Chione*. The taxonomy of *Austrovenus* is still unclear, and synonymising of some species by Beu *et al.* (1990) has resulted in only two recognised *Austrovenus* fossils. The extant *Austrovenus stutchbury* (Fig. 40) is Opoitian-Recent from the Waipaoa Beds, Awatere River, East Cape, Hawkes Bay, Clifden, and is a synonym of *Austrovenus crassitesta* Finlay, 1924 (Fig. 41). *Austrovenus tamakiensis* (Marwick, 1948) is from the Waipipian; Otahuhu Brewery well site (Fig. 42).

The anatomy and shell of *Austrovenus stutchburyi* differ from those of American *Chione* species and similarities are convergent (Jones 1979). Thus Finlay (1927: 470) was correct in commenting that "It [*A. stutchburyi*] compares well with no other *Chione*, and is a distinctive Neozelandic evolutionary product". *Austrovenus* is one of very few New Zealand venerids in which both radial and commarginal sculpturing are prominent. Fossil *Austrovenus* first appear
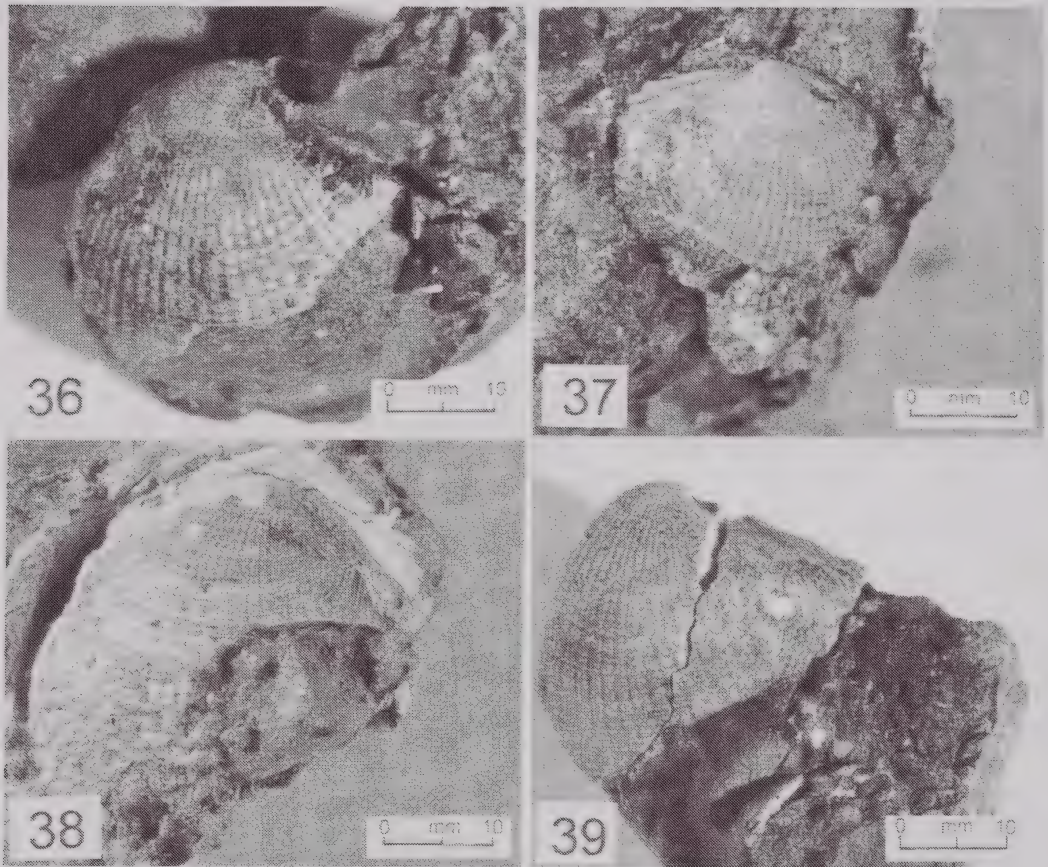
Figs 36-39. *Austrovenus northlandica* n. sp. 36. Holotype AK72649, lateral view of left valve. 37. Paratype AK72650, view of partial right valve and steinkern. 38. Paratype L3939, lateral view of right valve. 39. Paratype AK76823, view of posterior dorsal margin.

in a Waitakian assemblage exposed along the west bank of the Mataura River (F46/886313), near Brydone, Southland (Maxwell 1990). Shells from the Mataura site are small, not unlike *A. northlandica* in size, but lack the rounded, flattened margin, and a similar posterodorsal area of the lunule. Although forms of *A. stutchburyi* are similar in shape to *A. northlandica,* the shell of *A. stutchburyi* is larger, more robust, considerably more inflated, more strongly cancellated on the umbo, the escutcheon is less apparent, and the lunule is deeper, but not as broad or possessing as flattened a margin as in *A. northlandica*. *A. stutchburyi* forma *crassitesta* shares a triangular shape with *A. northlandica*, but is distinguishable by having thicker and more persistent concentric ridges and a deeper escutcheon.

The only other Recent *Austrovenus* species, *A. aucklandica* Powell, 1932, from the Auckland Islands, differs from *A. northlandica* by having an ovate-quadrate instead of an oval shell outline. *A. aucklandica* is less inflated than any of the forms of *A. stutchburyi*, but is similar in that respect to *A. northlandica*. However, the Auckland Island species differs in sculpture by having more radials, and by lacking concentric lamellae. The Pliocene fossil *A. tamakiensis* differs from *A. northlandica* in not being as inflated, in being more weakly sculptured, in having a relatively
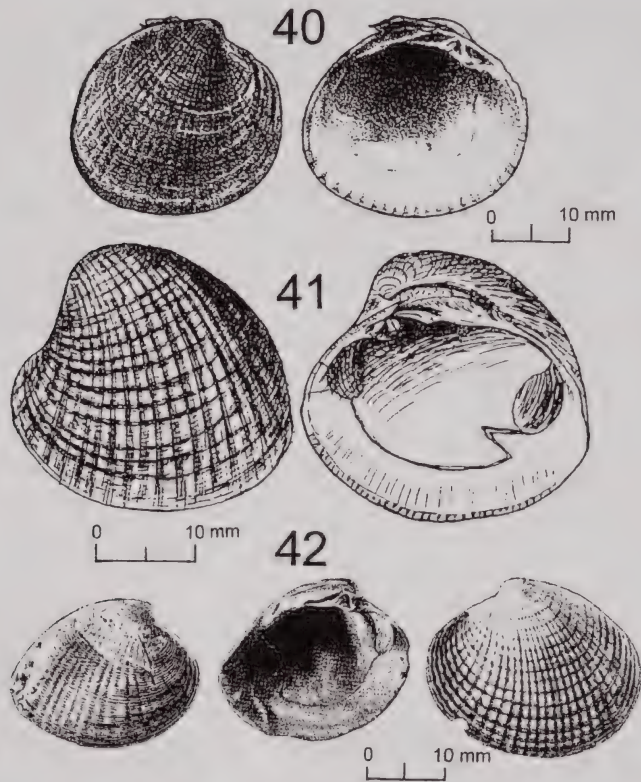
Figs 40-42. Line drawings of New Zealand fossil and Recent *Austrovenus* species. 40. *Austrovenus stutchburyi* (from Suter 1915). 41. *A. stutchburyi* forma *crassitesta* (from Beu *et al.* 1990). 42. *A. tamakiensis* (from Marwick 1948).

prominent escutcheon and in lacking the flattened broadness of lunular margin. In morphology, *A. northlandica* is unlike any other *Austrovenus*.

Records of *Austrovenus* from pre-Wanganui Series rocks are extremely scarce (Beu *et al.* 1990). Matura River Waitakian *Austrovenus* are rare, corroded single valves (indicating that they did not live in the immediate vicinity), found in decimetre to metre thick sandy shellbeds interbedded with carbonaceous fine sandstone and siltstone. *A. northlandica* originally lived in a shallow, subtidal mud and sand community (no deeper than 10 m), similar to the Mataura River fossil locality. *A. northlandica* is also found as single valves, but these are broken, rather than corroded, probably because of postmortem transport. Like the Mataura River specimens, *A. northlandica* is thought to have not lived in the immediate vicinity, but locally. It is likely that *A. northlandica* lived in a similar environmental setting to that of *A. stutchburyi*, i.e. at low tide in sand, gravel or mud of harbours, enclosed bays, mudflat estuaries, and brackish streams.

SUBCLASS:	ANOMALODESMATA Dall, 1889
ORDER:	PHOLADOMYOIDA Newell, 1965
SUPERFAMILY:	POROMYACEA Dall, 1886
FAMILY:	VERTICORDIIDAE Stoliczka, 1871

GENUS: *Euciroa* Dall, 1881

Type species: *Verticordia elegantissima* Dall, 1881 (by original designation). Recent, West Indies.

Diagnosis: Shell thin to solid, white, circular or elongate-ovate in shape, usually inflated; broadly rounded anteriorly, usually broadly truncated posteriorly; shell surface covered in radial ribs; beak prosogyarate; shell interior nacreous, ventral margin crenulated; mantle line continuous and uninterrupted; hinge a cardinal tooth in right valve below beak, left valve without true teeth; internal resilium lithodesma (Cox *et al.* 1969).
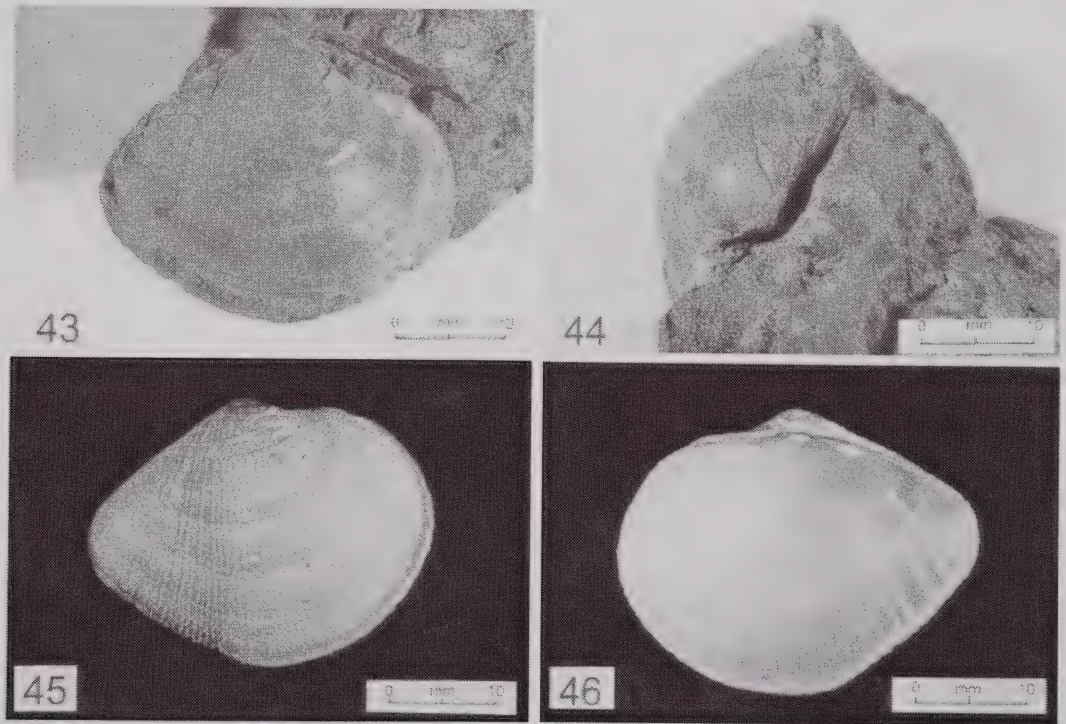
SUBGENUS: *Euciroa* Dall, 1881

Diagnosis: Valves subequal, hinge well-developed, rostrum reduced, flexure minimal (Cox *et al.* 1969).

Euciroa (Euciroa) maoriana n. sp. (Figs 43-50)

MATERIAL

Holotype: AK72657, adult right valve (Figs 43, 44); Waitakere Group, Manukau Subgroup, Nihotupu Formation, Maori Bay Member (Hayward 1976a), south end of Maori Bay, Q11/f40 (Fig. 3).

Figs 43-46. *Euciroa*. 43-44. New Zealand fossil *Euciroa (Euciroa) maoriana* n. sp. (holotype, AK72657). 43. Lateral view of right valve. 44. Dorsal view of right valve showing umbone detail. 45-46. Recent *E. galathea*. 45. Lateral external view of adult right valve. 46. Lateral internal view of adult right valve.

AGE

Pareora Series, early Altonian (Burdigalian), based on a K/Ar age of 16.8 Ma for the immediately overlying andesitic pillow lavas (Bandy *et al.* 1970).

ETYMOLOGY

Named after Maori Bay, Motutara.

DESCRIPTION

Shell inflated, thin, slightly gaping at each end, roundly ovate in outline, height 28.9 mm, length 33.8 mm, inflation 10.6 mm. Dorsal margin narrow, broadly rounded anteriorly. Ventral margin strongly convex, posterior slightly extended to produce sub-rostrate effect. Broad, shallow depression continues from beak toward posteroventral margin designating shell posterior. Prodissoconch rounded. Beak inflated, conspicuous, prosogyrate. Lunule large, prominent. Exterior shell sculpture of 72 spaced, continuous, narrow, granulose, radial riblets separated by dense sequence of narrow, then occasionally wide, narrow radial grooves crossed by irregular, commarginal, concentric growth lines on shell disc. Radial riblets 26 on posterior flexure, 15 on rostrum. Shell finely reticulated where ornament worn away. Posterior dorsal margin almost straight. Escutcheon small, indented. Shell internal characters not seen.

REMARKS

E. (Euciroa) maoriana is distinguished from New Zealand Recent *E. galathea* (Dell, 1956a)
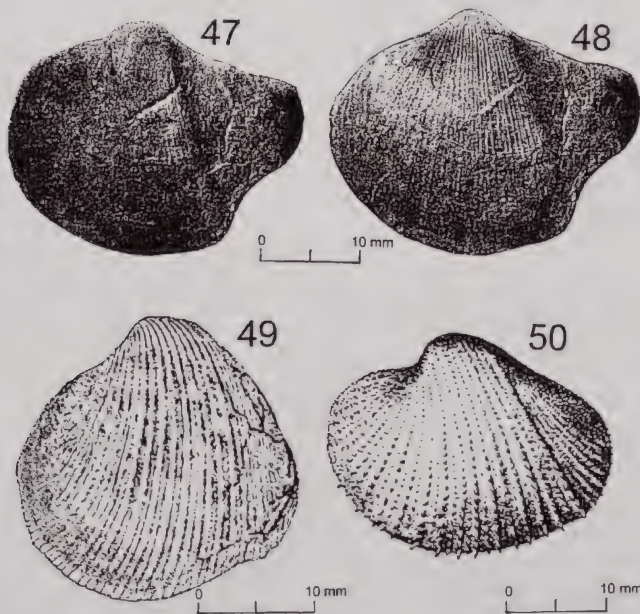
Figs 47-50. New Zealand fossil and foreign Recent *Euciroa*. 47. *E. ulrichi,* view of holotype left valve (from Fleming 1970). 48. *E. ulrichi,* composite of left valve. 49. *E. cistagemma,* view of right valve (from Keen 1958). 50. *E. elegantissima,* lateral view of left valve (from Cox *et al.* 1969).

(Figs 45, 46) by not having a triangular rostrum, by having a deeper, broader lunule, and by having finer, almost three times more numerous, radial riblets. *E. maoriana*, although identical in outline, also differs from *E. galathea* by having a less prominent posterior flexure, and an anteroventral quadrant that is less full and less inflated. The posteroventral margin is correspondingly straight in both species. The umbo is larger, more rounded at the prodissoconch and is not as obviously prosogyrate in *E. maoriana* as it is in *E. galathea*.

The poorly preserved New Zealand fossil *Euciroa ulrichi* Fleming, 1970 (Figs 47, 48) from the fine-grained Tarakohe Mudstone (Altonian), Tarakohe, north-west Nelson, differs from *E. (Euciroa) maoriana* by having a well-defined triangular rostrum separated from the shell disc by a distinct posterior flexure, which in *E. maoriana* is indistinct and minimal in comparison. Shell sculpture of *E. maoriana* and *E. ulrichi* consists of spaced, narrow radial riblets, increasing by interpolation and separated by radial grooves. The number and depth of these grooves and riblets differ between the species. In the holotype of *E. ulrichi*, every fourth to sixth groove may be deeper than the others. In the holotype of *E. maoriana* every ninth to tenth groove may be deeper and the corresponding ridge wider. The radial riblets of both species bear minute rounded pustules crossed by growth folds, and are higher and better defined toward the umbo than ventrally. Radial riblets tend to be poorly defined on the posterior rostrum and flexure. About 40 radial riblets occupy the shell disc in *E. ulrichi*; 14-18 on the posterior flexure and nine on the rostrum, the latter being supressed in some specimens. The holotype of *E. maoriana* has 72 radial riblets on the shell disc, 26 on the posterior flexure and 15 on the rostrum. *E. maoriana* is distinguished from the sole other New Zealand fossil *Euciroa, E. ulrichi*, by its more ovoid shape, reduced posteroventral embayment, weakened posterior flexure and number, consistency, and strength of radial riblets.

Although possessing some morphological similarities with the Recent Japanese species *E. cistagemma* Kuroda, 1968 (Pacific Ocean) (Fig. 49), *E. (Euciroa) maoriana* has many more finer radial riblets, a straighter anteroventral margin, and a very short rostrum that interrupts an oval shell outline. *E. cistagemma* does not possess a rostrum and has a trigonal shell outline. *E. elegantissima* Dall, 1881 (Florida to Cuba) (Fig. 50) is more oval in overall shell outline than *E. (Euciroa) maoriana*, and differs in having coarse radial ridges that are fewer in number (and covered in short spines), having an anteroventral margin that is not as straight. A combination of morphological features including overall shell outline, radial sculpturing, and details of rostrum and anteroventral margin, indicates that *E. (Euciroa) maoriana* is unlike any known *Euciroa*.

Euciroa is among the many molluscan taxa today restricted to, or most common in, the bathyal zone. It appears to be a widely distributed and characteristic member of the archibenthal fauna (Dell 1963). Recent species of *Euciroa* (Dell 1956b, 1963; Powell 1979) occur in depths of 475-621 m off Japan, Cuba, Florida, New Zealand, in the South Atlantic, and Indian Oceans. The Motutara bathyal assemblage seems to have existed in the upper part of the zone (c. 200-800 m), consistent with the suggestion of Beu *et al.* (1990).

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